

## Division Data Summary

### Research and Training Details

Number of Faculty	9
Number of Joint Appointment Faculty	1
Number of Research Fellows	21
Number of Research Students	13
Number of Support Personnel	18
Direct Annual Grant Support	\$4,676,640
Direct Annual Industry Support	\$5,000
Peer Reviewed Publications	49

## Significant Publications

Combs MD, Braitsch CM, Lange AW, James JF, Yutzey KE. **NFATc1 promotes epicardium-derived cell invasion into myocardium.** *Development*. [Research Support, N.I.H., Extramural]. 138(9):1747-57. May, 2011.

During development, epicardial cells on the surface of the heart invade the myocardium to form the coronary blood vessels and fibrous connective tissue. Michelle Combs, a graduate student in Dr. Katherine Yutzey's lab, discovered that the transcription factor NFATc1 is required for the myocardial invasion of epicardial cells. Studies in mice and chicken embryos demonstrate that loss of NFATc1 in epicardial cells prevents myocardial invasion, thus inhibiting the development of the coronary vessels and fibrous connective tissue of the heart. The invasion of myocardium by epicardial-derived cells is likely mediated by the NFATc1 downstream target gene cathepsin K, that encodes an extracellular matrix-degrading enzyme. Recently, epicardial cells have been identified as a source of regenerative cells in cardiovascular disease. Therefore, manipulation of the NFATc1 pathway could be exploited to promote the invasion or investment of progenitor cells in diseased hearts.

Goonasekera SA, Lam CK, Millay DP, Sargent MA, Hajjar RJ, Kranias EG, Molkentin JD. **Mitigation of muscular dystrophy in mice by SERCA overexpression in skeletal muscle.** *The Journal of clinical investigation*. [Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. 121(3):1044-52. Mar, 2011.

The Molkentin laboratory published a paper in *The Journal of Clinical Investigation* this past year in which they identified an entirely novel strategy for treating muscular dystrophy. Mice engineered to overexpress the protein SERCA in skeletal muscle showed substantial protection from mutations that normally lead to muscular dystrophy. Dr. Molkentin and colleagues also showed a gene therapy approach whereby transfer of the SERCA gene in skeletal muscle immediately corrected disease due to a Duchenne-like mutation in mice. These results suggest novel approaches to mitigate the underlying molecular defects that initiate skeletal muscle and cardiac cellular necrosis in muscular dystrophy by enhancing SERCA activity and/or expression. The laboratory is currently working on novel SERCA activating drugs that could also be employed to treat this disease in the near future.

Heineke J, Auger-Messier M, Correll RN, Xu J, Benard MJ, Yuan W, Drexler H, Parise LV, Molkentin JD. **CIB1 is a regulator of pathological cardiac hypertrophy.** *Nature medicine*. [Research Support, N.I.H., Extramural

Research Support, Non-U.S. Gov't]. 16(8):872-9. Aug, 2010.

This paper from the Molkentin laboratory identified a novel regulatory pathway that functions through the intracellular phosphatase calcineurin to regulate how the heart hypertrophies in response to disease inducing stimuli. The protein CIB1 was shown to modulate calcineurin signaling at the plasma membrane, and inhibition of CIB1 function reduced cardiac hypertrophy through calcineurin. This research suggests novel treatment angles for reducing pathological manifestations to the heart in response to disease inducing states.

Hinton RB, Adelman-Brown J, Witt S, Krishnamurthy VK, Osinska H, Sakthivel B, James JF, Li DY, Narmoneva DA, Mecham RP, **Benson DW**. **Elastin haploinsufficiency results in progressive aortic valve malformation and latent valve disease in a mouse model**. *Circulation research*. [Comparative Study Research Support, N.I.H., Extramural Research Support, Non-U.S. Gov't]. 107(4):549-57. Aug, 2010.

This paper describes a mouse model of latent and progressive aortic valve disease. Elastin (*Eln*) haploinsufficiency was induced by gene targeting. *Eln* null mice died in the perinatal period due to severe arterial obstruction, but the *Eln* haploinsufficient mice (*Eln*<sup>+/-</sup>) had normal longevity. Valvular interstitial cell activation and TGFβ receptor 1 downregulation is at least in part responsible for the pathogenesis in this model, resulting in hyperproliferation and maladaptive extracellular matrix remodeling. The valve cusp histopathology of the *Eln*<sup>+/-</sup> mice mimics the findings of human degenerative aortic valve disease, thus these mice thus have the potential of contributing to the development of novel therapeutics for patients with aortic valve disease.

## Division Highlights

### **Joshua Waxman, PhD**

The Waxman lab's recent work has focused on factors that affect cardiac progenitor specification and indicates that cardiac and forelimb progenitors interact, helping to direct each ones' development. Specifically, we have found that retinoic acid signaling acting on forelimb progenitors impacts fibroblast growth factor signaling, which acts on cardiac progenitors. Together, these interactions allow proper specification of these different fields. We think elucidating these interactions will allow us to understand developmental syndromes that result in both heart and forelimb defects.

## Division Collaboration

**Human Genetics** » Teresa Smolarek, PhD; Sarah Zimmerman, PhD

Study of microarray abnormalities in patients with cardiovascular malformations, funded by a grant through the March of Dimes.

**Allergy and Immunology; Gastroenterology** » Marc Rothenberg, MD, PhD; Philip Putnam, MD; James Franciosi, MD, MS, MSCE

TGF beta dysregulation: understanding the relationship in patients with eosinophilic esophagitis and connective tissue abnormalities.

**Biomedical Informatics** » Bruce Aronow, PhD

Use of systems biology to identify genetic regulatory networks for cardiomyopathy.

## Faculty Members

**Jeffrey Robbins, PhD**, Professor

*Executive Co-Director, The Heart Institute*

*Associate Chair of the CCHMC*

*Endowed Chair for Molecular Cardiovascular Biology*

**Research Interests** Mechanisms of Normal and Abnormal Cardiovascular function

**James Gulick, MS**, Instructor

**Research Interests** Molecular interactions between certain cardiac contractile proteins and how such interactions can be altered by mutations that are associated with cardiomyopathies

**Jeanne James, MD**, Associate Professor

*Director, Mouse Echocardiography Core*

**Research Interests** Manifestations and etiologies of misfolded protein response and echocardiography

**Zaza Khuchua, PhD**, Associate Professor

**Research Interests** Congenital cardiac disorders caused by inborn errors in mitochondrial energy-producing enzymes, and model systems to study molecular mechanisms of these diseases

**Marjorie Maillet, PhD**, Instructor

**Research Interests** Understanding signaling pathways that lead to heart disease

**Jeffery Molkentin, PhD**, Professor

*Howard Hughes Medical Institute Investigator*

**Research Interests** Molecular pathways that underlie heart disease and muscular dystrophy

**Stephanie Ware, MD, PhD**, Associate Professor

*Director of Research and Development, Associate Medical Director, The Heart Institute Diagnostic Laboratory  
Co-Director, Cardiovascular Genetics*

**Research Interests** Genetics of pediatric heart disease

**Joshua Waxman, PhD**, Assistant Professor

**Research Interests** Molecular Genetics of Heart Development

**Katherine Yutzey, PhD**, Professor

**Research Interests** Heart development and disease mechanisms

## Joint Appointment Faculty Members

**D Woodrow Benson, MD, PhD**, Professor

Cardiology

**Research Interests** Genetic basis of pediatric heart disease

## Trainees

- Federica Accornero, PhD, University of Turin, Italy
- Mannix Auger-Messier, PhD, University of Sherbrooke, Canada
- Md. Shenuarin Bhuiyan, PhD, Tohoku University, Japan
- Caitlin Braitsch, BS, Xavier University
- Adam Burr, BS, University of Minnesota, Twin Cities
- Ashley Cast, BA, Augustana College
- Santanu Chakraborty, PhD, Miami University
- Michelle Combs, BS, Quincy University
- Robert Nathan Correll, PhD, University of Kentucky
- Jason Cowan, MS, University of Miami
- Enrico D'Aniello, PhD, Marine Zoological Station Anton Dohrn, Italy

- Jennifer Davis, PhD, University of Michigan, Ann Arbor
- Tracy Dohn, BS, Wittenberg University
- Petra Eder, PhD, University of Graz, Austria
- John Elrod, PhD, Albert Einstein College of Medicine
- Ambrose Goonasekera, PhD, University of Rochester
- Manish Gupta, PhD, University of Cincinnati
- Mary Lee, MS, Ball State University
- Jason Karch, BA, Dakota Wesleyan University
- Izhak Kehat, PhD, Technion-Israel Institute of Technology, Israel
- Jennifer Kwong, PhD, Weill Medical College of Cornell University
- Ruijie Liu, PhD, University of Illinois at Urbana Champaign
- Jeffrey Lynch, PhD, University of Alberta, Canada
- Patrick McLendon, PhD, Virginia Polytechnic Institute and State University
- Timothy Mead, BS, University of Dayton
- Diana Nardini, BS, College of Mount St. Joseph
- Ariel Rydeen, BS, University of Minnesota
- Arunima Sengupta, PhD, Miami University
- Mardi Sutherland, BS, University of Massachusetts, Boston
- Muhammad Tariq, PhD, Quaid-I-Azam University, Pakistan
- Jop van Berlo, MD, PhD, University Hospital Maastricht, Netherlands
- Davy Vanhoutte, PhD, University of Leuven, Belgium
- Elaine Wrigg, PhD, Medical University of South Carolina
- Erin Wissing, BA, DePauw University

## Division Publications

1. Acehan D, Vaz F, Houtkooper RH, James J, Moore V, Tokunaga C, Kulik W, Wansapura J, Toth MJ, Strauss A, Khuchua Z. **Cardiac and skeletal muscle defects in a mouse model of human Barth syndrome**. *The Journal of biological chemistry*. 2011; 286:899-908.
2. Bolli R, Stein AB, Guo Y, Wang OL, Rokosh G, Dawn B, Molkentin JD, Sanganalmath SK, Zhu Y, Xuan YT. **A murine model of inducible, cardiac-specific deletion of STAT3: its use to determine the role of STAT3 in the upregulation of cardioprotective proteins by ischemic preconditioning**. *Journal of molecular and cellular cardiology*. 2011; 50:589-97.
3. Breitbart A, Auger-Messier M, Molkentin JD, Heineke J. **Myostatin from the heart: local and systemic actions in cardiac failure and muscle wasting**. *American journal of physiology. Heart and circulatory physiology*. 2011; 300:H1973-82.
4. Chakraborty S, Wrigg EE, Hinton RB, Merrill WH, Spicer DB, Yutzey KE. **Twist1 promotes heart valve cell proliferation and extracellular matrix gene expression during development in vivo and is expressed in human diseased aortic valves**. *Developmental biology*. 2010; 347:167-79.
5. Ch'en IL, Tsau JS, Molkentin JD, Komatsu M, Hedrick SM. **Mechanisms of necroptosis in T cells**. *The Journal of experimental medicine*. 2011; 208:633-41.
6. Chen X, Nakayama H, Zhang X, Ai X, Harris DM, Tang M, Zhang H, Szeto C, Stockbower K, Berretta RM, Eckhart AD, Koch WJ, Molkentin JD, Houser SR. **Calcium influx through Cav1.2 is a proximal signal for pathological cardiomyocyte hypertrophy**. *Journal of molecular and cellular cardiology*. 2011; 50:460-70.
7. Combs MD, Braitsch CM, Lange AW, James JF, Yutzey KE. **NFATC1 promotes epicardium-derived cell invasion into myocardium**. *Development*. 2011; 138:1747-57.

8. Czosek RJ, Haaning A, Ware SM. **A mouse model of conduction system patterning abnormalities in heterotaxy syndrome.** *Pediatric research.* 2010; 68:275-80.
9. Eder P, Molkentin JD. **TRPC channels as effectors of cardiac hypertrophy.** *Circulation research.* 2011; 108:265-72.
10. Elrod JW, Wong R, Mishra S, Vagnozzi RJ, Sakthivel B, Goonasekera SA, Karch J, Gabel S, Farber J, Force T, Brown JH, Murphy E, Molkentin JD. **Cyclophilin D controls mitochondrial pore-dependent Ca(2+) exchange, metabolic flexibility, and propensity for heart failure in mice.** *The Journal of clinical investigation.* 2010; 120:3680-7.
11. Fakhro KA, Choi M, Ware SM, Belmont JW, Towbin JA, Lifton RP, Khokha MK, Brueckner M. **Rare copy number variations in congenital heart disease patients identify unique genes in left-right patterning.** *Proceedings of the National Academy of Sciences of the United States of America.* 2011; 108:2915-20.
12. Force T, Bonow RO, Houser SR, Solaro RJ, Hershberger RE, Adhikari B, Anderson ME, Boineau R, Byrne BJ, Cappola TP, Kalluri R, LeWinter MM, Maron MS, Molkentin JD, Ommen SR, Regnier M, Tang WH, Tian R, Konstam MA, Maron BJ, Seidman CE. **Research priorities in hypertrophic cardiomyopathy: report of a Working Group of the National Heart, Lung, and Blood Institute.** *Circulation.* 2010; 122:1130-3.
13. Froese N, Kattih B, Breitbart A, Grund A, Geffers R, Molkentin JD, Kispert A, Wollert KC, Drexler H, Heineke J. **GATA6 promotes angiogenic function and survival in endothelial cells by suppression of autocrine transforming growth factor beta/activin receptor-like kinase 5 signaling.** *The Journal of biological chemistry.* 2011; 286:5680-90.
14. Gilio K, Harper MT, Cosemans JM, Konopatskaya O, Munnix IC, Prinzen L, Leitges M, Liu Q, Molkentin JD, Heemskerk JW, Poole AW. **Functional divergence of platelet protein kinase C (PKC) isoforms in thrombus formation on collagen.** *The Journal of biological chemistry.* 2010; 285:23410-9.
15. Goonasekera SA, Lam CK, Millay DP, Sargent MA, Hajjar RJ, Kranias EG, Molkentin JD. **Mitigation of muscular dystrophy in mice by SERCA overexpression in skeletal muscle.** *The Journal of clinical investigation.* 2011; 121:1044-52.
16. Harper MT, Molkentin JD, Poole AW. **Protein kinase C alpha enhances sodium-calcium exchange during store-operated calcium entry in mouse platelets.** *Cell calcium.* 2010; 48:333-40.
17. Heineke J, Auger-Messier M, Correll RN, Xu J, Benard MJ, Yuan W, Drexler H, Parise LV, Molkentin JD. **CIB1 is a regulator of pathological cardiac hypertrophy.** *Nature medicine.* 2010; 16:872-9.
18. Hinton RB, Adelman-Brown J, Witt S, Krishnamurthy VK, Osinska H, Sakthivel B, James JF, Li DY, Narmoneva DA, Mecham RP, Benson DW. **Elastin haploinsufficiency results in progressive aortic valve malformation and latent valve disease in a mouse model.** *Circulation research.* 2010; 107:549-57.
19. Hinton RB, Michelfelder EC, Marino BS, Bove KE, Ware SM. **A fetus with hypertrophic cardiomyopathy, restrictive, and single-ventricle physiology, and a beta-myosin heavy chain mutation.** *The Journal of pediatrics.* 2010; 157:164-6.
20. Hinton RB, Yutzey KE. **Heart valve structure and function in development and disease.** *Annual review of physiology.* 2011; 73:29-46.
21. James J, Robbins J. **Signaling and myosin-binding protein C.** *The Journal of biological chemistry.* 2011; 286:9913-9.
22. Kehat I, Accornero F, Aronow BJ, Molkentin JD. **Modulation of chromatin position and gene expression by HDAC4 interaction with nucleoporins.** *The Journal of cell biology.* 2011; 193:21-9.
23. Kehat I, Davis J, Tiburcy M, Accornero F, Saba-EI-Leil MK, Maillet M, York AJ, Lorenz JN, Zimmermann WH, Meloche S, Molkentin JD. **Extracellular signal-regulated kinases 1 and 2 regulate the balance between eccentric and concentric cardiac growth.** *Circulation research.* 2011; 108:176-83.
24. Kehat I, Molkentin JD. **Molecular pathways underlying cardiac remodeling during pathophysiological stimulation.** *Circulation.* 2010; 122:2727-35.

25. Korf-Klingebiel M, Kempf T, Schluter KD, Willenbockel C, Brod T, Heineke J, Schmidt VJ, Jantzen F, Brandes RP, Sugden PH, Drexler H, Molkentin JD, Wollert KC. **Conditional transgenic expression of fibroblast growth factor 9 in the adult mouse heart reduces heart failure mortality after myocardial infarction.** *Circulation*. 2011; 123:504-14.
26. Lincoln J, Yutzey KE. **Molecular and developmental mechanisms of congenital heart valve disease.** *Birth defects research. Part A, Clinical and molecular teratology*. 2011; 91:526-34.
27. Maloyan A, Robbins J. **Autophagy in desmin-related cardiomyopathy: Thoughts at the halfway point.** *Autophagy*. 2010; 6:665-666.
28. Meissner M, Weissgerber P, Londono JE, Prenen J, Link S, Ruppenthal S, Molkentin JD, Lipp P, Nilius B, Freichel M, Flockerzi V. **Moderate calcium channel dysfunction in adult mice with inducible cardiomyocyte-specific excision of the cacnb2 gene.** *The Journal of biological chemistry*. 2011; 286:15875-82.
29. Nakayama H, Bodi I, Maillet M, DeSantiago J, Domeier TL, Mikoshiba K, Lorenz JN, Blatter LA, Bers DM, Molkentin JD. **The IP3 receptor regulates cardiac hypertrophy in response to select stimuli.** *Circulation research*. 2010; 107:659-66.
30. Qian L, Wythe JD, Liu J, Cartry J, Vogler G, Mohapatra B, Otway RT, Huang Y, King IN, Maillet M, Zheng Y, Crawley T, Taghli-Lamalle O, Semsarian C, Dunwoodie S, Winlaw D, Harvey RP, Fatkin D, Towbin JA, Molkentin JD, Srivastava D, Ocorr K, Bruneau BG, Bodmer R. **Tinman/Nkx2-5 acts via miR-1 and upstream of Cdc42 to regulate heart function across species.** *The Journal of cell biology*. 2011; 193:1181-96.
31. Sengupta A, Molkentin JD, Paik JH, DePinho RA, Yutzey KE. **FoxO transcription factors promote cardiomyocyte survival upon induction of oxidative stress.** *The Journal of biological chemistry*. 2011; 286:7468-78.
32. Spicer RL, Ware SM. **Diseases of the Myocardium.** *Nelson textbook of pediatrics*. Philadelphia, PA: Elsevier/Saunders; 2011: 1 online resource (p.). .
33. Spicer RL, Ware SM. **Diseases of the Pericardium.** *Nelson textbook of pediatrics*. Philadelphia, PA: Elsevier/Saunders; 2011: 1 online resource (p.). .
34. Spicer RL, Ware SM. **Tumors of the Heart.** *Nelson textbook of pediatrics*. Philadelphia, PA: Elsevier/Saunders; 2011: 1 online resource (p.). .
35. Stanley BA, Graham DR, James J, Mitsak M, Tarwater PM, Robbins J, Van Eyk JE. **Altered myofilament stoichiometry in response to heart failure in a cardioprotective alpha-myosin heavy chain transgenic rabbit model.** *Proteomics. Clinical applications*. 2011; 5:147-58.
36. Stefater JA, 3rd, Lewkowich I, Rao S, Mariggi G, Carpenter AC, Burr AR, Fan J, Ajima R, Molkentin JD, Williams BO, Wills-Karp M, Pollard JW, Yamaguchi T, Ferrara N, Gerhardt H, Lang RA. **Regulation of angiogenesis by a non-canonical Wnt-Flt1 pathway in myeloid cells.** *Nature*. 2011; 474:511-5.
37. Sugden PH, Markou T, Fuller SJ, Tham el L, Molkentin JD, Paterson HF, Clerk A. **Monophosphothreonyl extracellular signal-regulated kinases 1 and 2 (ERK1/2) are formed endogenously in intact cardiac myocytes and are enzymically active.** *Cellular signalling*. 2011; 23:468-77.
38. Sun T, Wu XS, Xu J, McNeil BD, Pang ZP, Yang W, Bai L, Qadri S, Molkentin JD, Yue DT, Wu LG. **The role of calcium/calmodulin-activated calcineurin in rapid and slow endocytosis at central synapses.** *The Journal of neuroscience : the official journal of the Society for Neuroscience*. 2010; 30:11838-47.
39. Tang M, Li J, Huang W, Su H, Liang Q, Tian Z, Horak KM, Molkentin JD, Wang X. **Proteasome functional insufficiency activates the calcineurin-NFAT pathway in cardiomyocytes and promotes maladaptive remodelling of stressed mouse hearts.** *Cardiovascular research*. 2010; 88:424-33.
40. Tang M, Zhang X, Li Y, Guan Y, Ai X, Szeto C, Nakayama H, Zhang H, Ge S, Molkentin JD, Houser SR,

- Chen X. **Enhanced basal contractility but reduced excitation-contraction coupling efficiency and beta-adrenergic reserve of hearts with increased Cav1.2 activity.** *American journal of physiology. Heart and circulatory physiology.* 2010; 299:H519-28.
41. van Berlo JH, Elrod JW, van den Hoogenhof MM, York AJ, Aronow BJ, Duncan SA, Molkentin JD. **The transcription factor GATA-6 regulates pathological cardiac hypertrophy.** *Circulation research.* 2010; 107:1032-40.
  42. Wansapura JP, Millay DP, Dunn RS, Molkentin JD, Benson DW. **Magnetic resonance imaging assessment of cardiac dysfunction in delta-sarcoglycan null mice.** *Neuromuscular disorders : NMD.* 2011; 21:68-73.
  43. Ware SM. **Genetic diagnosis in pediatric cardiomyopathy: clinical application and research perspectives.** *Progress in pediatric cardiology.* 2011; 31:99-102.
  44. Waxman JS, Yelon D. **Zebrafish retinoic acid receptors function as context-dependent transcriptional activators.** *Developmental biology.* 2011; 352:128-40.
  45. Wirrig EE, Hinton RB, Yutzey KE. **Differential expression of cartilage and bone-related proteins in pediatric and adult diseased aortic valves.** *Journal of molecular and cellular cardiology.* 2011; 50:561-9.
  46. Wirrig EE, Yutzey KE. **Transcriptional regulation of heart valve development and disease.** *Cardiovascular pathology : the official journal of the Society for Cardiovascular Pathology.* 2011; 20:162-7.
  47. Wissing ER, Millay DP, Vuagniaux G, Molkentin JD. **Debio-025 is more effective than prednisone in reducing muscular pathology in mdx mice.** *Neuromuscular disorders : NMD.* 2010; 20:753-60.
  48. Yamaguchi N, Chakraborty A, Pasek DA, Molkentin JD, Meissner G. **Dysfunctional ryanodine receptor and cardiac hypertrophy: role of signaling molecules.** *American journal of physiology. Heart and circulatory physiology.* 2011; 300:H2187-95.
  49. Zhang H, Chen X, Gao E, MacDonnell SM, Wang W, Kolpakov M, Nakayama H, Zhang X, Jaleel N, Harris DM, Li Y, Tang M, Berretta R, Leri A, Kajstura J, Sabri A, Koch WJ, Molkentin JD, Houser SR. **Increasing cardiac contractility after myocardial infarction exacerbates cardiac injury and pump dysfunction.** *Circulation research.* 2010; 107:800-9.

## Grants, Contracts, and Industry Agreements

Grant and Contract Awards	Annual Direct / Project Period Direct
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### BRAITSCH, C

**Tbx18 Regulation of Epicardial-Derived Cell Proliferation, Migration and Differentiation in Cardiac Development**

American Heart Association

07/01/09-06/30/11

\$23,000

### CORRELL, R

**Regulation of Cardiac Gene Expression by the L-type Calcium Channel, CaV1.2**

National Institutes of Health

F32 HL 097551

09/07/09-09/06/12

\$50,474

### DAVIS, J

**The Non-Hypertrophic Role of Calcineurin in Regulating Cardiac Structure-Function**

National Institutes of Health

F32 HL 095353

12/15/08-12/14/11

\$52,154

### KARCH, J

**The Role of Bax and Bak in Necrotic Cell Death**

American Heart Association

	07/01/10-06/30/12	\$23,000
<b>KHUCHUA, Z</b>		
<b>The shRNA-Mediated Tafazzin Knockdown Mouse Model</b>		
Barth Syndrome Foundation, Inc.		
	01/01/10-12/31/11	\$16,361
<b>KRISHNAMURTHY, V</b>		
<b>Valve Tissue Mechanics and Cell Phenotype in a Mouse Model of Aortic Valve Disease</b>		
American Heart Association		
	07/01/09-06/30/11	\$23,000
<b>MAILLET, M</b>		
<b>Role of IP-3 Mediated Calcium Release in Cardiac Hypertrophic Cardiomyopathy</b>		
National Institutes of Health		
R21 HL 097186	04/15/10-03/31/12	\$125,000
<b>MOLKENTIN, J</b>		
<b>Calcium as a Molecular Signal in the Heart</b>		
National Institutes of Health(Temple University School of Medicine)		
R01 HL 089312	08/15/07-06/30/12	\$239,303
<b>Cardiac Hypertrophic Intracellular Signaling Pathways</b>		
National Institutes of Health		
R01 HL 062927	02/01/09-12/31/13	\$250,000
<b>Molecular Pathways Controlling Cardiac Gene Expression</b>		
National Institutes of Health		
R37 HL 060562	07/01/08-06/30/13	\$250,000
<b>Thrombospondin 4 Regulates Adaptive ER Stress Response</b>		
National Institutes of Health		
R01 HL 105924	01/01/11-12/31/11	\$315,000
<b>RAZZAQUE, A</b>		
<b>Cardiomyopathic Mechanisms in Pediatric Congenital Disease</b>		
American Heart Association		
	07/01/10-06/30/12	\$43,000
<b>ROBBINS, J</b>		
<b>Cardiac Myosin Binding Protein-C: Structure, Function and Regulation</b>		
National Institutes of Health(University of Vermont)		
P01 HL 059408	02/01/10-01/31/15	\$356,105
<b>Nikon A1 Confocal Microscope</b>		
National Institutes of Health		
S10 RR 027014	07/01/10-06/30/11	\$388,205
<b>Signaling Processes Underlying Cardiovascular Function</b>		
National Institutes of Health		
P01 HL 069779	01/11/08-12/31/12	\$1,219,260
<b>SENGUPTA, A</b>		
<b>URC Postdoctoral Fellow Research Grant</b>		
University of Cincinnati		
	01/01/11-12/31/11	\$5,000
<b>VAN BERLO, J</b>		
<b>GATA-6 Function is Crucial for Cardiac Hypertrophy to Prevent Heart Failure</b>		
American Heart Association		
	07/01/10-06/30/12	\$43,000

<b>WARE, S</b>		
<b>Role of the Embryonic Node in Cardiac Development and Congenital Heart Disease</b>		
National Institutes of Health		
R01 HL 088639	04/01/07-03/31/12	\$250,000
<b>Uncovering Novel Genetic Causes and Risk in Congenital Heart Disease Patients</b>		
Burroughs Wellcome Foundation(University of Cincinnati)		
1008496	07/01/09-06/30/14	\$75,000
<b>Genetic Causes of Congenital Heart Defects</b>		
March of Dimes		
	06/01/10-05/31/13	\$93,866

<b>WAXMAN, J</b>		
<b>Elucidation of Molecular Networks Required to Limit Cardiac Cell Number</b>		
National Institutes of Health		
R00 HL 091126	07/15/10-05/31/13	\$163,368
<b>Illumination of Mechanisms Controlling Atrial Cell Formation</b>		
March of Dimes National		
	02/01/11-01/31/13	\$69,327

<b>YUTZEY, K</b>		
<b>Notch Signaling in Heart Valve Development and Disease</b>		
National Institutes of Health		
R01 HL 094319	07/01/09-06/30/11	\$308,217
<b>The Function of Notch1 in Heart Valve Development</b>		
American Heart Association		
	07/01/09-06/30/11	\$23,000
<b>Twist 1 Regulation of Valve Progenitors</b>		
National Institutes of Health		
R01 HL 082716	07/01/10-05/31/15	\$250,000
<b>Weinstein Cardiovascular Development Conference 2011</b>		
March of Dimes National		
	04/01/11-09/30/11	\$2,000
<b>Student Undergraduate Research Fellowships</b>		
American Heart Association		
	06/01/10-05/31/12	\$20,000

**Current Year Direct      \$4,676,640**

Industry Contracts

<b>YUTZEY</b>		
Genetech, Inc		\$5,000
<b>Current Year Direct Receipts</b>		<b>\$5,000</b>

**Total      \$4,681,640**